

AN EVALUATION OF SUB-ZERO TEMPERATURES ON SOUTHERN PINE
BEETLE POPULATIONS IN NORTH CAROLINA, TENNESSEE
AND GEORGIA

By

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INTRODUCTION

During January 1977, the southern Appalachian area experienced below normal temperatures. Records show that January had the lowest average temperature for any month on record. Near zero and below zero (°F) temperatures were recorded on several days during the month. This study was conducted by the Forest Insect and Disease Management Group to determine the impact of the cold temperatures on the southern pine beetle (Dendroctonus frontalis Zimm) population. The report also covers, briefly, the past history of cold temperatures and beetle mortality, and factors that may affect brood survival. Observations and data collected on southern pine beetles this spring will be combined with this information to project the southern pine beetle conditions for summer 1977.

LITERATURE REVIEW

Past History of Cold Temperature Effects on Southern Pine Beetle

Several instances of southern pine beetle mortality following periods of unusually cold temperatures have been recorded. Hopkins (1899) initially attributed the decline of the southern pine beetle outbreak in West Virginia to a severe freeze in the winter of 1892-93. A sudden drop in temperature in the winter of 1926-27) caused heavy brood mortality around Asheville, N.C. (Beal, 1927). Knull (1934) reported brood mortality due to minimum temperatures during 1930-31 in Chambersburg and Gettysburg, Pennsylvania. Again in 1957-58 subzero temperatures occurred in the southern Appalachians, causing 95 to 100 percent mortality in all brood stages except the egg stage; the epidemic was expected to be at low levels in 1959 (Anonymous, 1958b). In Alabama, temperatures in

the mountain areas dropped to near zero temperature causing heavy southern pine beetle mortality in 1958 and no active spots had been found four months later (Anonymous, 1958a). In 1970, several days of temperatures as low as -16°F occurred in the southern Appalachians causing over 95 percent brood mortality (Flavell, et. al., 1970).

Evaluations conducted in the spring of 1970 indicated that southern pine beetle populations were low on some of the areas that had been sampled for winter mortality, such as the Cheoah Ranger District (Clerke and Wilson, 1970) and the Wayah Ranger District (Ward, Bassett and Wilson, 1970a). However, in other areas, such as the Tusquitee Ranger District, beetle populations were low, but beginning to increase (Ward, Bassett and Wilson, 1970b). By the fall of 1970 populations had built up to a significantly potential level on the Tellico Ranger District in Tennessee (Ward, 1970) and were continuing to increase on the Tusquitee Ranger District (Ward and Wilson, 1970). In December 1971, it was reported that southern pine beetle populations were again causing heavy timber mortality on the Cheoah Ranger District and the Great Smoky Mountains National Park (Barry and Wilson, 1971), and were continuing to cause damage on the Tusquitee (Rauschenberger and McDowell, 1971) and Tellico (Ward and Clerke, 1971) Ranger Districts.

Factors Influencing Cold Temperature Mortality.

Causes for brood mortality can be due to cold temperatures alone or in combination with several other factors. Different brood stages were less susceptible than others. Beal (1933) found field temperatures of -5°F did not appear to affect the eggs but caused 100% mortality in larvae and Fronk (1947) found eggs exposed to 0°F for one week were able to hatch. Beal (1927, 1933) noted that it was significant that all mortality occurred in that portion of the brood occupying the phloem or inner bark, and that brood in the outer bark survived. Moisture content was the only apparent difference. He felt this was the result of possibly two reasons: 1) high moisture undoubtedly would affect the brood both through contact and through their feeding on moist food material, 2) brood in the inner bark were in an active feeding stage that would be more susceptible than prepupal larvae in a hibernating or dormant state which are usually found in the outer bark (Beal, 1933). Somme (1963) found that glycerol accumulated in the fall in several species of diapausing insects. The presence of glycerol increased the cold-hardiness of the insects by lowering the super cooling points.

Massey and Wygant (1954) and Frye, Flake and Germain (1974) found that large numbers of spruce beetles (D. engelmanni Hopk) were killed when low temperatures occurred in the early fall or winter before the beetles had developed cold-hardiness.

Bark thickness was also a factor in affecting beetle survival. Beal (1934) found that thicker bark provided more protection for western pine beetle (D. brevicomis, Lee). Thin bark closely followed the trend of air temperatures while thicker bark responded more slowly and required a longer time to cool to temperatures fatal to the brood. When air temperatures dropped as low as -26°F, for a short time only, the sub-cortical temperatures in trees ranged from 8 to 29 degrees higher. In Alabama (Anonymous, 1958a) following the freeze in 1958, all southern pine beetle adults and larvae in the thin-barked Virginia pine were dead, while populations in the loblolly pine had been reduced by two-thirds.

Hopkins (1899) attributed the decline of a southern pine beetle outbreak in West Virginia in 1893 to a combination of unusually low temperatures and disease. Dead larvae and pupae that he examined had the appearance of insects that had died from a bacterium disease. He concluded while the severe cold and subsequent changes in temperature killed many of the insects, others were weakened and subsequently overcome by disease. Andrewartha and Birch (cited in Moore, 1971) noted that low temperature and high moisture create a condition unfavorable to insect growth but favorable to pathogenic bacteria and fungi. Moore (1971) found that disease was more prevalent in the winter and spring than during the summer and fall and among beetles in Virginia pine than among those in shortleaf or loblolly pine. He also found that pathogenic organisms destroyed nearly one-third of the brood each year.

Parasites and predators are apparently more resistant to cold temperatures than bark beetles. Frye, et. al. (1974) observed an apparent resistance to cold in the predators and parasites associated with spruce beetle. During the winter of 1957-58 there was 95 to 100 percent mortality to southern pine beetle brood and only 40 percent mortality for clerid beetles (Anonymous, 1958b).

METHODS AND MATERIALS

Seven areas in the southern Appalachians were sampled for the evaluation. Areas were selected on the basis of a recent history of southern pine beetle activity. These are: 1) Asheville Area, N.C.; 2) Henderson County, N.C.; 3) Grandfather Ranger District, Pisgah National Forest, N.C.; 4) Tusquitee Ranger District, Nantahala National Forest, N.C.; 5) Nolichucky Ranger District, Cherokee National Forest, Tennessee; 6) Unaka Ranger District, Cherokee National Forest, Tennessee; and 7) Chickamauga-Chattanooga National Military Park, Georgia. (Figure 1).

A total of 18 spots that were known to be active last fall were sampled within each area. Trees within the spots were checked to determine the current status and activity of the brood. Bark samples were taken at breast height from the north and south side of each sample tree. Sampling was biased towards those trees in which live brood were found. Samples were taken to the laboratory where they were trimmed to a 4x6 inch sample and dissected by hand to determine the number of live and dead brood. Brood categories were divided into parent adults, young larvae, older larvae and pupae, and callow adults. Notation was also made as to whether the live or dead beetles were found in the outer bark or the cambium. Percent mortality was based on the numbers of live + 1 dead brood in the bark samples.

Weather records for the month of January for North Carolina and Tennessee were obtained from the National Climatic Center in Asheville, N.C. The weather records for Chattanooga, Tennessee were used for the Chickamauga-Chattanooga National Battlefield Park, Georgia.

Additional information on the status of southern pine beetle populations was provided by state entomologists based on their field observations.

RESULTS AND DISCUSSION

Past records have shown that below normal cold temperatures have caused substantial southern pine beetle mortality. Table 1 and Figure 2 give the lowest temperatures reported for the month of January 1977 at various U. S. Weather Bureau Reporting Stations throughout the North Carolina-Tennessee area. Although January 1977 was reported as having

the lowest mean average temperature recorded, temperatures in many areas did not drop as low as those reported in January 1970 (Table 2). Other areas reported temperatures that were lower.

Table 3 shows the percent brood mortality from the samples collected in each area. With the exception of the Chickamauga-Chattanooga National Military Park, there was 100% mortality in parent adults. Many of the trees examined were successfully attacked by the parent adults, but the adults were encrusted in pitch within the galleries. There was little evidence of any brood. Also, abnormally shaped galleries indicated adults attacking last fall were under a stress situation, possibly a combination of an already declining beetle population and unfavorable environmental conditions. In the samples collected in the six North Carolina-Tennessee areas there was an estimated 88% total beetle mortality. Actual percent mortality may be higher and closer to the 90-95% reported by most states due to the bias in the sampling method. Brood survival was dependant on a tree by tree basis. Brood in the dry outer bark or in thick-barked shortleaf trees had a higher percent survival than brood in the thinner barked Virginia pine. Temperatures were colder than normal, however, they did not drop and hold at a level that would be sufficient to cause 100% brood mortality in all areas. In addition, temperatures under thick bark tend to be several degrees higher than the ambient air temperatures. In order for the cold to kill the insect the temperature must drop below the super cooling point for that species.

There was an increased brood mortality due to cold temperatures. That, plus an already declining population, and the cold predisposing the brood to disease, combine to cause high mortality. This may result in an endemic southern pine beetle situation throughout most of the southern Appalachians. In areas of epidemic status, as in the Chickamauga-Chattanooga National Military Park there was only 21% total mortality, and it is doubtful that the insect status will change much on the Park.

The southern pine beetle is capable of producing five or six generations per year and the potential for population build-up over the summer exists even with the small number of surviving beetles if conditions are favorable. This was essentially the situation in 1970 when many low spring populations increased to epidemic proportions by fall.

Keen and Furniss (1937) pointed out that even a severe reduction of brood by cold weather has no lasting effect upon epidemic trends and that these trends are primarily influenced by other factors. However, it is expected that southern pine beetle populations will remain at endemic levels throughout the southern Appalachian area for the summer and fall of 1977.

SUMMARY

A survey was conducted to determine the effect of cold temperatures in January 1977 on southern pine beetle populations in the southern Appalachians. There was a total brood mortality of 88% in Tennessee and North Carolina, but could be as high as 95%. The effects of cold temperatures and disease on an already declining population is expected to result in endemic populations for summer 1977. The effects of cold temperatures on areas that had epidemic populations such as the Chickamauga-Chattanooga National Military Park is not expected to be noticeable.

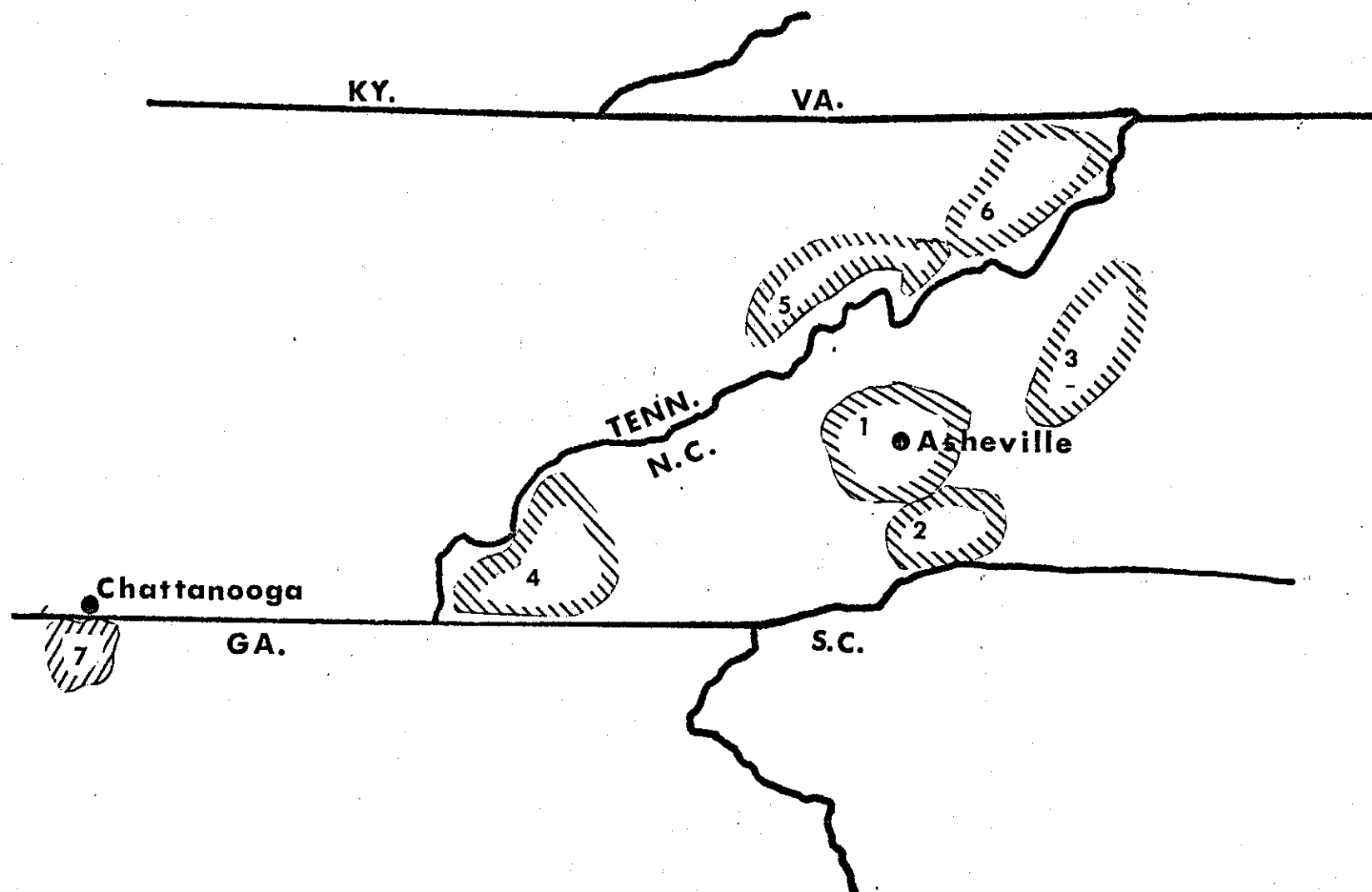


Figure 1: Locations of the seven sample areas used in collecting data for determining the effects of cold temperatures on southern pine beetle brood during the winter of 1976-77. Areas were designated: 1) Asheville Area, 2) Henderson Co. Area, 3) Grandfather Ranger District, 4) Tusquitee Ranger District, 5) Nolichucky Ranger District, 6) Unaka Ranger District, and 7) Chickamauga-Chattanooga National Military Park.

Table 1: January temperature data for reporting stations in and around areas sampled for southern pine beetle mortality in North Carolina and Tennessee, 1977.

North Carolina

Station	Lowest Temp.	Date	Number of Days			
			Maximum 90° or above	Maximum 32° or below	Minimum 32° or below	Minimum 0° or below
Andrews	0	30	0	10	30	4
Asheville WSO AP	- 5	17	0	10	31	3
Asheville	- 6	17	0	11	30	2
Bent Creek	- 7	17	0	8	30	2
Blowing Rock	-17	17	0	17	31	10
Boone	-13	17	0	19	31	5
Franklin	- 2	17	0	6	31	4
Grandfather Mt.	-20	17	0	25	31	13
Hendersonville	- 6	17	0	9	29	2
Hot Springs	- 7	17	0	13	30	2
Lenoir	- 1	17	0	5	29	1
Marion	0	17	0	7	31	1
Murphy	- 5	17	0	9	30	3
Tuckasegee	- 4	17	0	10	31	6
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TENNESSEE						
Bristol WSO AP	- 7	17	0	17	30	3
Chattanooga WSO AP	- 2	17	0	8	26	1
Cleveland	- 5	17	0	8	29	3
Gatlinburg	-10	17	0	12	31	3
Greenville Exp Sta	- 9	18	0	15	30	2
Kingsport	- 6	17	0	12	29	1
Newport	- 6	17	0	13	30	2
Norris	-11	17	0	9	31	4
Unicoi	-13	17	0	12	29	2
Watauga Dam	- 9	18	0	13	36	6

Table 2: Minimum temperatures for January 1970 compared to those reported in January 1977 for various U.S. Weather Bureau Reporting Stations in the North Carolina-Tennessee Area.

WEATHER STATION	1970	1977
<u>North Carolina</u>		
Andrews	-10	0
Cataloochee	-12	- 9
Cullowhee	-10	- 3
Franklin	-11	- 2
Hot Springs	- 5	- 7
Tuckasegee	- 8	- 4
Waterville	- 3	- 9
Waynesville	-16	- 5
<u>Tennessee</u>		
Athens	- 5	- 6
Cleveland	- 4	- 5
Copper Hill	- 4	- 4
Gatlinburg	- 9	-10
Lenoir City	- 2	- 5
Sevierville	-15	-14

Table 3: Percent mortality of southern pine beetles in bark samples collected to determine the effects of cold temperatures in January 1977.

Sample Area	Parent Adults	Young larvae	% Mortality Older larvae & pupae	Callow Adults	Total
Asheville	100%	-	-	-	100%
Henderson Co.	100%	-	-	-	100%
Grandfather RD	88%	83%	22%	-	69%
Tusquitee RD	100%	47%	56%	-	75%
Nolichucky RD	100%	100%	100%	-	100%
Unaka RD	100%	68%	90%	-	86%
Chickamauga- Chattanooga NMP	87%	100%	6%	0% *	21%
*all callow adults were alive					

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